REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate only, other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Infomration Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (07804-0188), Washington, DC 20503.			
1. AGENCY USE ONLY *(LEAVE BLANK)*	2. REPORT DATE 11 August 1995	3. REPORT TYPE AND DATES COVERED Professional Paper	
4. TITLE AND SUBTITLE Integrated New Test Aircraft Capability (INTAC)		5. FUNDING NUMBERS	
6. AUTHOR(S) Dean Carico			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Visual and Technical Information Branch 7.2.4.3.A, Mail Stop 2, Bldg. 405 Naval Air Warfare Center Aircraft Division Patuxent River, Maryland 20670-5304		8. PERFORMING ORGANIZATION REPORT NUMBER DTIC ELECTE NOV 09 1995	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Air Systems Command Department of the Navy 1421 Jefferson Davis Highway Arlington, VA 22243		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution is unlimited.			12b. DISTRIBUTION CODE
13. ABSTRACT *(Maximum 200 words)* *SEE ATTACHED PAPER*			
14. SUBJECT TERMS Combat System Test Bed;R&D,Mobile Demonstration		15. NUMBER OF PAGES 32 16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19.SECURITY CLASSIFICATION OF ABSTRACT N/A	20. LIMITATION OF ABSTRACT N/A

NAVAIR 779

CLEARANCE REQUEST FOR PUBLIC RELEASE OF DEPARTMENT OF DEFENSE INFORMATION

TO: Assistant Secretary of Defense (Public Affairs)

ATTN: Director, Freedom of Information & Security Review, Rm. 2C757, Pentagon

(This form is to be used in requesting review and clearance of DoD information proposed for public release in accordance with DoDD 5230.9)

1. DOCUMENT DISCRIPTION

a. TYPE Technical Paper	b. TITLE Integrated New Test Aircraft Capability (INTAC)
c. PAGE COUNT 9	d. SUBJECT AREA Developmental Testing

2. AUTHOR/SPEAKER

a. NAME (Last, First, MI) CARICO, DEAN	b. RANK	c. TITLE
	d. OFFICE Rotary Wing A/C Test Squadro	e. AGENCY Naval Air Warfare Center A/C Div.

3. PRESENTATION/PUBLICATION DATA

Presentation at the ITEA International Symposium on 2-5 October in Huntsville, AL.

4. POINT OF CONTACT	5. PRIOR COORDINATION
a. NAME (Last, First, MI) GREENE, GRACE A.	a. OFFICE Public Affairs
b. TELEPHONE NUMBER 703-604-2822, X4605	b. AGENCY Naval Air Systems Command

No Security Objection to Open Publication (AS AMENDED)
95-C-0516
AUG 09 1995
Office of the Chief of Naval Operations
Dept. of the Navy

6. REMARKS

Document has been reviewed by AIR-4.1C, AIR-1.6, AIR-7.4.1 and AIR-7.5.1.

7. RECOMMENDATION OF SUBMITTING OFFICE/AGENCY

a. The attached material has Department/Office/Agency approval for public release (qualifications if any, are indicated in Remarks Section) and clearance for open publication is recommended under provisions of DoDD 5230.9. I am authorized to make this recommendation for release on behalf of:

CLEARED
FOR OPEN PUBLICATION
AUG 11 1995 2
DIRECTORATE FOR FREEDOM OF INFORMATION AND SECURITY REVIEW (OASD-PA)
DEPARTMENT OF DEFENSE

b. Clearance is requested by: 950816 (YYMMDD)

c. NAME (Last, First, MI) GREENE, GRACE A.	d. TITLE Public Affairs Spec.	e. SIGNATURE Grace A. Greene
f. OFFICE Public Affairs	g. AGENCY Naval Air Systems Command	h. DATE (YYMMDD) 950807

ITEA INTERNATIONAL SYMPOSIUM

REINVENTING T&E
Doing It Better, Faster, Cheaper.....

2-5 Oct 1995, Huntsville, AL

INTEGRATED NEW TEST AIRCRAFT CAPABILITY (INTAC)

Dean Carico, 4K3200A
Naval Air Warfare Center Aircraft Division
Rotary Wing Aircraft Test Squadron
Building 2113 22621 Saufley Rd M/S 1
Patuxent River, MD 20670-5304
Fon 301-342-1382, Fax 301-342-1340

Enclosure (1)

Abstract

The current and projected emphasis on declining budgets, reduced staffs, and tightened schedules, while trying to maintain or improve productivity, dictates a new approach to T&E that takes advantage of the ongoing technology explosion. Automation and standardization, combined with analysis and high technology simulation options, permit a new look at traditional Developmental Testing (DT). This proposed concept, called Integrated New Test Aircraft Capability (INTAC), involves using a high-fidelity, physical model based, generic structure simulation to certify the aircraft in a virtual environment, and using the aircraft to certify the simulation model. INTAC includes supporting, enhancing, augmenting, and ultimately automating traditional T&E and making this capability available at the pilot/engineer work area. INTAC promises to reinvent T&E by allowing test team members to do testing better, faster, cheaper, and safer. A high fidelity virtual air vehicle life cycle simulation capability, like INTAC, also gives the program manager better information on how to optimize the application of scarce future test dollars.

Reinventing T&E

Why reinvent T&E? Consider all the aircraft that have been through the T&E cycle. If something is not broke, why fix it? Also note that powered aircraft flight testing has been ongoing since at least the turn of the century. Back in 1903, when the Wright Brothers were inventing powered aircraft flight, the philosophy was essentially "fly-fix-fly". The early T&E pioneers were often "jacks-of-all-trades" who performed aircraft design, construction, flight testing, repair, redesign, and marketing. As we approach the 21st century, factors such as economics, safety, timeliness, and technology suggest that is time to take a new look at T&E.

Current Approach

As we approach the 21st century, T&E has taken on a team approach. It may be done in the form of an integrated test team (ITT), integrated product team (IPT), an enterprise team, a systems team, or a joint service team. These teams are usually supported by large test range facilities and/or complex systems engineering test facilities. These facilities may have been initiated back in the 60's and 70's, when T&E cost was not a major obstacle, and new aircraft were continuously being acquired. Today, few new aircraft appear on the horizon. Defense spending is being reduced, along with the federal defense work force. This implies that if for no other reason than economics, it is important to reinvent T&E.

In the current peace time environment, T&E safety is paramount. In the early days of aviation, it was not unusual to lose aircraft during the T&E process. Today T&E safety can not be overstressed, and from a safety view point, it is important to always work to reinvent T&E to make it safer.

Many flight testers grew up with the Cold War helping to fuel the T&E pace. Today the Cold War is over and there are no major wars to drive the aircraft acquisition cycle. Most regional conflicts happen rapidly with little time to plan and prepare. If planning a flight test program, instrumenting the test aircraft, flying the test program, reducing the test data, and writing the test report took 6 months each, it would take approximately 3 years to get the final test results to the sponsor. This implies that it is important to reinvent T&E, by do it more quickly.

We thus need to reinvent T&E by doing it cheaper, quicker, and safer. Each of these areas are important, but the primary focus on reinventing T&E should be on doing it better, and that is were current and future technology options come into focus.

Technology Picture

Try to picture aircraft and T&E support technology options available in the past (1903), at the present time (1995), and in the future (2010). Aircraft technology improvements can be demonstrated by comparing yesterday's Wright Brothers bi-wing Flyer aircraft to today's Bell/Boeing V-22 tilt rotor Osprey. The Flyer featured mechanical controls, including wing warping. The V-22 has a triple redundant fly-by-wire digital primary flight control system and an automatic flight control system. Future aircraft configuration choice is anyone's guess, but the trend will probably continue toward fewer new aircraft and virtual aircraft development and testing. These future multi-company and multi-national aircraft will probably incorporate the latest technology in air vehicle, systems, and warfighting, while trying to maintain affordability.

Early aircraft T&E support was performed by a single individual or small group of entrepreneurs using very rudimentary tools by today's standards. Today's T&E teams have modern test ranges and sophisticated systems engineering facilities, in addition to personal computers, to support their test programs. Most of today's T&E technology options available at the large systems engineering facilities are not available at the test engineer's work area. T&E technology today needs to be reinvented and relocated to provide the test engineer with greatly enhanced capability to solve tomorrow's "What if ......?" questions. It is important to reinvent T&E by bringing technology options in flight test automation to the test engineer's work area.

Acquisition Cycle

In the past, and even today, T&E is often though of as developmental testing or DT testing. If the team philosophy of supporting aircraft systems from concept to disposal, is important in the future, then it is important to use simulation models that address aircraft design, acquisition, testing, and operations for the life cycle. This implies that the model structure should be capable of supporting the test and acquisition process through decision point milestones 0-IV. It is important to reinvent T&E by adding life cycle support options to today's "T&E only" simulation models.

Integrated New Test Aircraft Capability

The proposed INTAC concept involves developing, testing, validating, and applying an advanced generic simulation that automates rotorcraft flight testing and warfighting in the at-sea environment (reference 1). A goal is to allow the flight test engineer to develop a comprehensive flight test plan in one day, and run the complete test plan test matrix overnight on his PC tied into a workstation. If aircraft NATOPS flight limits, applicable specification limits, and component load limits were build into the program, these limits could be displayed on the output data. Including this information as an appendix to the test plan would give management information on how close the flight testing would approach specified limits. Being able to analytically run a flight test program in one day would permit rapid answers to sponsor "What if ....?" questions. The INTAC capability is transferable both vertically and horizontally to existing systems engineering facilities and test range facilities. It could also provide life cycle systems engineering support, including design trade-off studies. The proposed INTAC capability would reinvent rotorcraft flight testing and analysis by allowing it to be done better, faster, cheaper, and safer.

Generic Simulation Structure

The heart of the INTAC program is a generic structure simulation. The generic structure permits rapid modeling of a variety of rotorcraft to selected levels of fidelity for real time or non-real time analysis. Requirements include the ability to run real time elastic blade element models and to predict steady and vibratory component loads in real time. The simulation structure must have a flight test front end to enhance it's application in a flight testing environment.

Test Planning, Data Analysis, & Reporting

Comprehensive test planning is the key to a successful flight test program. An INTAC focus includes working to help automate rotorcraft flight test project management, test planning, data reduction/analysis/presentation, and test reporting. A variety of Artificial Intelligence (AI) technologies, including case-based reasoning and voice recognition are used in automating flight testing, as show in figure 1. This Automated Flight Test Engineering System (AFTES) also interfaces with a myriad of state-of-art software including word processing, spread sheets, simulation, and frequency domain analysis programs. These programs, plus others and lessons learned data bases, are all tied into the flight test engineer's PC via AFTES, as shown in figure 2. The case-based reasoning technology means that the engineer will have the benefit of all previous test plans in the data base for reference. Having access to previous test plans, to lesson learned data bases, and state-of-the-art support software, all on the PC, allows the engineer to reinvent test planning by doing it better, quicker, and cheaper.

Rotorcraft flight test data reduction, data analysis, and data presentation require specialized software, and is often the reason for delays in the final report publication. Data reduction techniques for standard tests are described in the US Navy Test Pilot School manuals, references 2 and 3. Many state-of-the-art software packages could be used to enhance data analysis, but the programs do not contain user friendly flight test front ends. When the engineer has a full work load conducting a flight test program, time may not be available to learn new software. AFTES builds a transparent interface with the analysis software permitting the engineer to readily apply it to his flight test program.

The test report conveys results to the sponsors, and the format may include a message report, a quick response report, and/or report of test results. Much of the report background information and data for the appendices can be obtained from the test plan. The report results and discussion, conclusions, and recommendations sections also follow specified writing formats. This implies that a program like AFTES could automate a significant portion of flight test report writing, permitting it to be done quicker and cheaper.

Test planning and reporting could be further enhanced if they were tied into other related ongoing programs. The Office of the Secretary of Defense (OSD) is sponsoring an effort to use expert system based tools to focus on automating the Test and Evaluation Master Plan (TEMP). This program, called Automated Test Planning System (ATPS), involves a joint service approach to enhance and standardize TEMP development and review, as discussed in reference 4. At the same time, the Army is working to develop a Test and Evaluation Plan (TEP) Builder to eliminate redundancy and improve the quality of Operational Test (OT) plans, as described in reference 5. The TEMP defines the T&E requirements for major systems acquisition, and if this information was available for the AFTES, then flight test competency leaders could better schedule their workforce. If the results of AFTES were available to the operational TEP builder, it would provide an enhanced relationship between DT and OT . This concept is illustrated in table 1.

Rotorcraft Flight Testing

Rotorcraft flight testing may include classical air vehicle flying qualities and performance, or more specialized testing like reliability and maintainability (R&M), dynamic interface (DI), and warfighting, as summarized in table 2. These tests may be performed on a large variety of Navy and other service rotorcraft as summarized in table 3. Typical real time rotorcraft models that can be used to support some basic flight testing are inadequate to support R&M or DI flight testing. To adequately support R&M testing it is necessary to predict steady and vibratory loads. Currently no non-real time code or real time helicopter code can accurately predict helicopter vibratory loads. The INTAC program proposal includes developing the capability to predict rotorcraft loads in real time. The second part of this problem involves measuring the rotor blade motion, plus aerodynamic, structural, and inertial loads during flight testing for model validation data. Rotorcraft blade loads have been measured in the past, in a few isolated cases, primarily at research facilities. The requirement to use pressure sensors and strain gages on the blades has been too costly for flight test facilities, both in terms of money and installation time. One part of the INTAC program includes developing novel instrumentation to measure rotor blade motion and loads on any rotorcraft. This effort involves using accelerometers and kinematic observer software that is relatively cheap, easy to install, and applicable to every rotorcraft. The accelerometer and kinematic observer software approach promises to help reinvent T&E by making blade motion and load measurements available to flight test facilities.

Navy At-sea Environment

Navy at-sea scenarios also present unique flight test requirements. Environmental factors like ship wind-over-the-deck speed and direction, and ship motion are difficult to control, as discussed in reference 6. Helicopter/ship or DI operational envelope testing is relatively expensive, it is difficult to get ships scheduled for DI testing, and it is not possible to control the weather to get high relative winds and sea states. The capability to develop helicopter/ship operational flight envelopes analytically would reinvent at-sea testing by doing it better, faster, cheaper, and safer. Analytical approaches to DI testing have been suggested since 1984, but this capability does not currently exist. In fact, the current generation of operational flight trainers (OFT) (cost up to approximately $30M) are not authorized for basic deck landing qualification (DLQ) training. Before the pilot is permitted to conduct standard aircraft shipboard operations, he must perform DLQ landings under relatively benign conditions with an instructor pilot. Simulation factors needing improvement include ship airwake and motion models, rotor blade models, and visual systems, also the simulator pilot stress factor needs to be closer to that of the real aircraft.

The INTAC program proposes a systematic approach to develop improved real time ship airwake models. This approach includes:

- Enhancing ship airwake measuring equipment
- Conducting at-sea ship airwake measurements
- Generating CFD ship airwake data
- Developing real-time ship airwake models
- Validating the improved ship airwake models

The current state-of-the-art in measuring full scale ship airwake data is movable 30 foot masts, that have three sets of u, v, and w propeller anemometers, located at different heights. This system allows quantitative measurements over a single spot on the ship flight deck. Instrumentation is needed to make volumetric airwake measurements over the ship deck and in the aircraft approach and departure corridors. Computational fluid dynamics (CFD) techniques can be used to generate air wake data for specified volumes around the ship, and can be used to supplement full scale measurements over the ship flight deck. The INTAC program proposes to use full scale airwake data or CFD data for the steady airwake component and a stochastic approach to develop the turbulence airwake model component. Again, improved real time ship airwake models are needed to reinvent T&E in the at-sea environment.

Warfighting

Future possible conflicts in areas such as Haiti, the Persian Gulf, Somalia, Bosnia, etc., point out the requirement for rapid response multi-service aircraft ship-based operations. The pilot is required to recognize threats, employ required countermeasures, perform the intended mission, and land safely aboard ship. Pilot workload can be compounded by future high technology air and ground weaponry threats. Avionic task automation in the form of AI technology applied to intelligent threat warning and countermeasure resource optimization could greatly reduce pilot workload and improve safety. The warfighting INTAC focus involves developing, validating, and demonstrating intelligent threat warning, countermeasure optimization, and pilot training automation in a virtual environment at the engineer work area. The concept uses AI technology to help enhance and automate Naval rotorcraft warfighting, in a virtual environment at the engineer's work area. This concept could be used to reinvent avionic system T&E, doing it better, faster, and cheaper.

Virtual World

Reinventing T&E in the 21st century should include virtual reality options at the flight test engineer's work area. Virtual reality has been called a science, a technology, a business, and a phenomena that is supported by significant funding from numerous industries worldwide, and DOD. Reference 6 notes that more than 80% of the total cost of a system is determined by decisions made prior to the engineering and manufacturing development phase of acquisition. Considerable progress has been made in rapid prototyping and simulation, but the goal should be to develop the capability to test a virtual aircraft in a virtual environment by test team members at their work area. This concept would reinvent T&E, making it better, faster, cheaper, and safer. Having this virtual capability would help support the concept of using simulation to certify the aircraft, and using the aircraft to certify the simulation. Today's test ranges and systems engineering facilities would still be used to evaluate the actual aircraft, but flight time and support cost could be minimized.

Summary

The current and projected emphasis on declining budgets, reduced staffs, and tightened schedules, while trying to maintain or improve productivity, dictates a new approach to T&E that takes advantage of the ongoing technology explosion. As we approach the 21st century, factors such as economics, safety, timeliness, and technology suggest that it is time to reinvent T&E. One option involves developing the capability to help automate rotorcraft design, test planning, and flight testing in a virtual environment at the test team members work area, as shown in figure 3. This proposed concept, called INTAC, involves using a high-fidelity, physical model based, generic structure simulation to certify the aircraft in a virtual environment, and using the aircraft to certify the simulation model. Artificial intelligence techniques are used to automate test project management, test plan development, data reduction/analysis/presentation, and test reporting. The generic model simulation would permit the complete test plan flight test matrix to be run on a PC, networked to a workstation, prior to even seeing the test aircraft. The rotorcraft simulation capability to predict steady and vibratory aircraft component loads in real time is needed to support R&M testing. Improved real time ship airwake models are needed to support and enhance helicopter/ship dynamic interface testing. Intelligent threat warning and countermeasure resource optimization capability are needed for avionic task automation. Considerable progress has been made in rapid prototyping and simulation, but the goal should be to develop the capability to test a virtual aircraft in a virtual environment by test team members at their work area.

Acknowledgments

The author gratefully acknowledges the vision and support of Mr. Bob Bailey (AIR 4.1C) and the members of the AERMIP team in their work to improve R&M and DI testing, and flight testing in general.

The author also acknowledges the work of the other members of the INTAC Advanced Technology Proposal team: Mission Research Corporation (team leader), Advanced Rotorcraft Technology, Stottler Henke and Associates, Continuum Dynamics Incorporation, Georgia Institute of Technology, and the University of Texas at Austin.

References

1. Chapman, George B., "Integrated New Test Aircraft Capability," Mission Research Corporation White Paper MRC-P-4072.02, Nov 1994.

2. Higgins, L. and Hanks, M., Rotary Wing Performance," USNTPS-FTM-No. 106, Dec 1987.

3. Higgins, L. and Hanks, M., Rotary Wing Stability and Control," USNTPS-FTM-No. 107 (Preliminary), Jan 1991.

4. Roth, M. Scott, "Automated Test Planning System," ITEA Journal, Volume 16, Number 1 of March/April 1995.

5. Wyant, Kerry W.; Page, Walton Johnson, Jr.; and Ward, Alan C., "The Test and Evaluation Plan (TEP) Builder: An Overview," ITEA Poster Session, Dec 1993.

6. Carico, D. and Madey, S., Jr., "Dynamic Interface: Conventional Flight Testing Plus A New Analytical Approach," AHS National Specialist's Meeting on Helicopter Testing Technology, Williamsburg, VA., Oct 1984.

7. Garcia, Albert B., LtCol, USA, et. al., Virtual Prototyping: Concept to Production, Report of the DSMC 1992-1993 Military Research Fellows, Mar 1994.

Table 1
DT and OT Test Planning Support

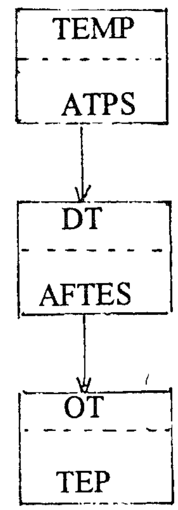

Table 2
Types of Rotorcraft Testing

Flying Qualities	Flight Control Systems
Performance	Engine Evaluations
Avionics	Structural Demonstration
Warfighting	Trainer Validation Data
Dynamic Interface	Reliability & Maintainability

Table 3
Rotorcraft Simulation Models Needed

AH-1W	V-22	TH-57C
UH-1N	CH-46E	SH-60B
SH-2G	UH-46D	SH-60F
UH-3H	CH-53D	HH-60H
VH-3D	RH-53D	HH-60J
	CH-53E	
	MH-53E	

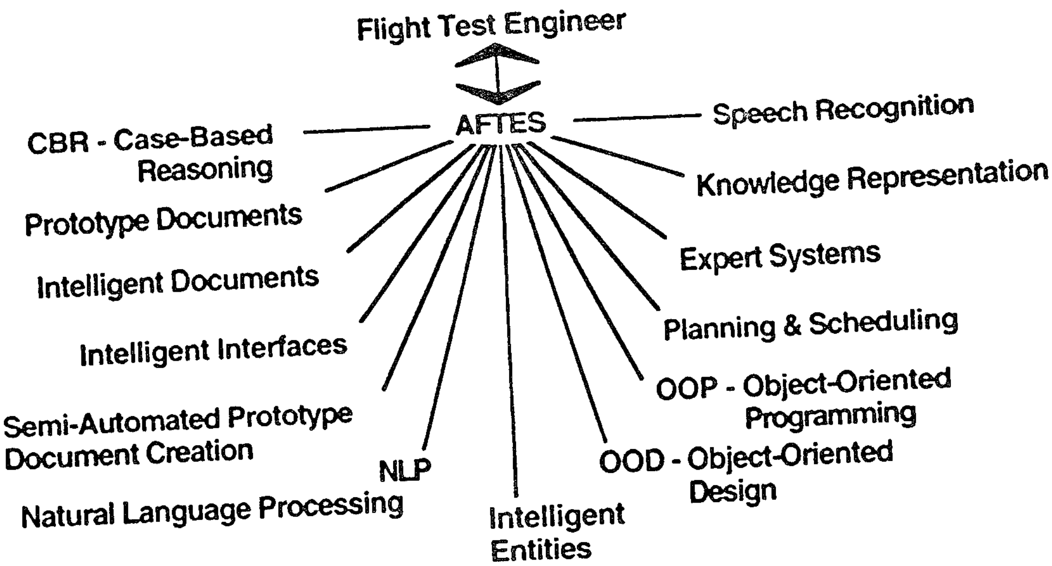

Figure 1
AFTES - AI Techniques
(Courtesy SHAI, Belmont, CA)

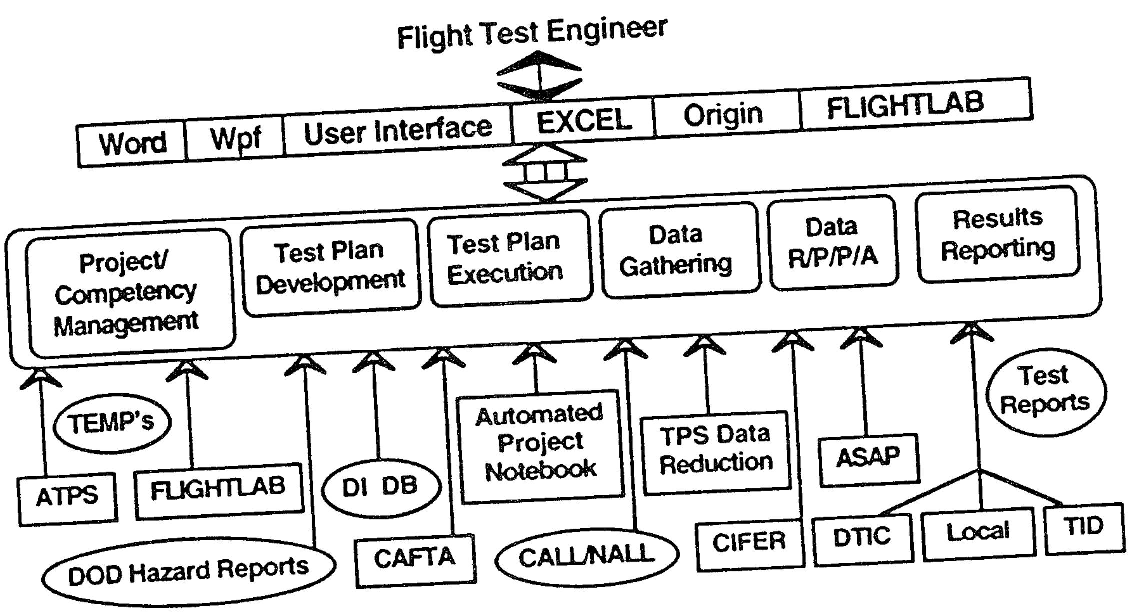

Figure 2
Automated Flight Test Engineering System
(Courtesy SHAI, Belmont, CA)

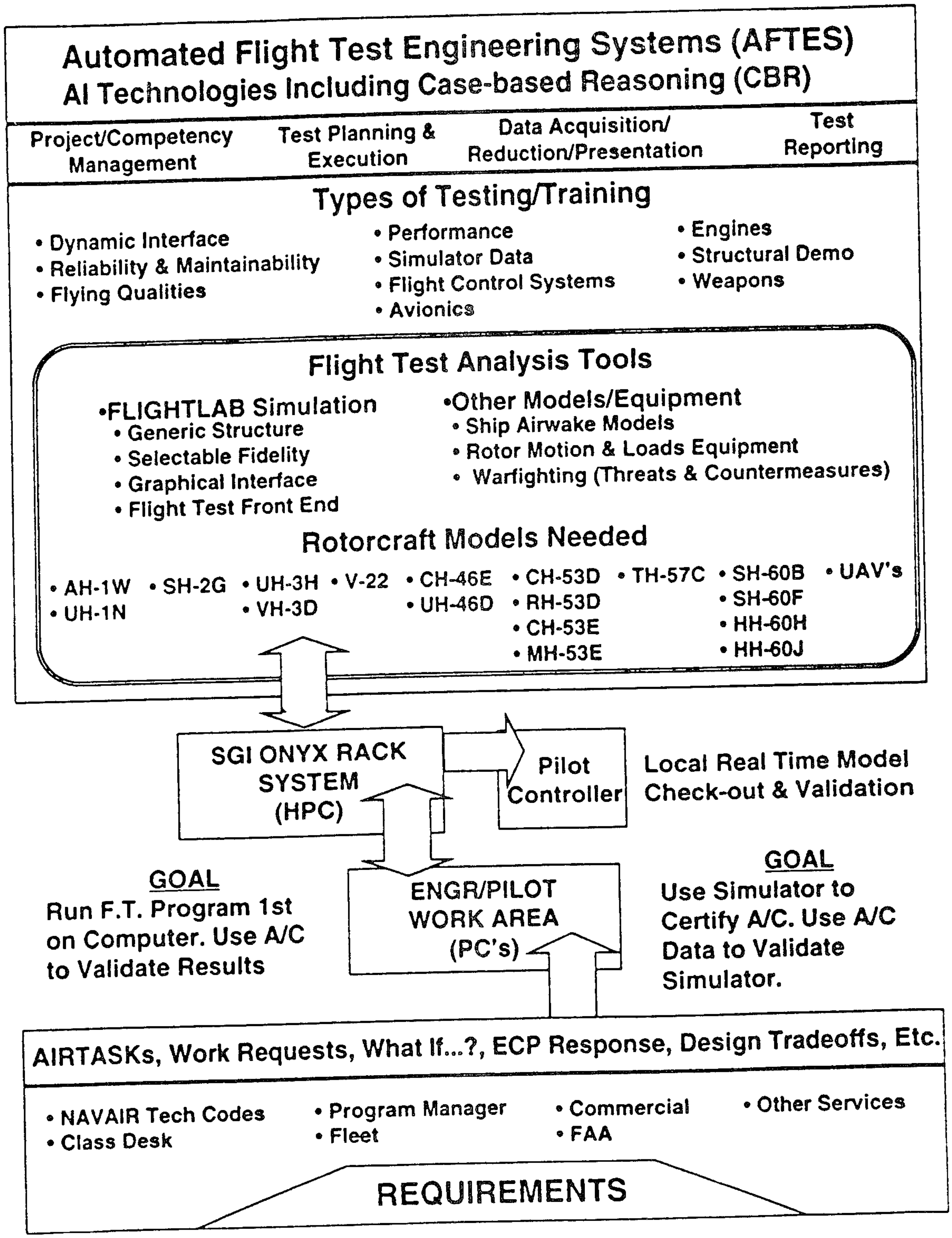

Figure 3
Flight Test Automation Overview